

UNCLASSIFIED

AD NUMBER

AD815690

LIMITATION CHANGES

TO:

Approved for public release; distribution is unlimited.

FROM:

Distribution authorized to U.S. Gov't. agencies and their contractors; Critical Technology; APR 1967. Other requests shall be referred to Air Force Technical Applications Center, Washington, DC 20333. This document contains export-controlled technical data.

AUTHORITY

usaf ltr, 25 jan 1972

THIS PAGE IS UNCLASSIFIED

AD815690

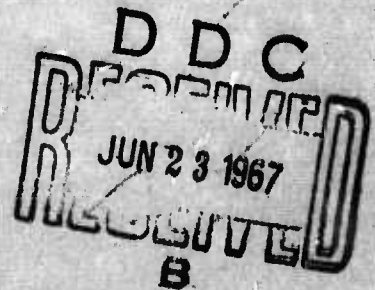
TECHNICAL REPORT NO. 67-31

OPERATION OF UBSO-QUARTERLY REPORT NO. 4

1 February 1967 through 30 April 1967

STATEMENT #2 UNCLASSIFIED

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of *AFJAC, WASH, D.C. 20333*



GEOTECH

A TELEDYNE COMPANY

TECHNICAL REPORT NO. 67-31

OPERATION OF UBSO, QUARTERLY REPORT NO. 4
1 February 1967 through 30 April 1967

Sponsored by

Advanced Research Projects Agency
Nuclear Test Detection Office
ARPA Order No. 624

GEOTECH
A TELEDYNE COMPANY
3401 Shiloh Road
Garland, Texas

19 May 1967

IDENTIFICATION

AFTAC Project No:	VELA T/6705
Project Title:	Operation of UBSO
ARPA Order No:	624
ARPA Program Code No:	6F10
Name of Contractor:	Teledyne Industries, Geotech Division Garland, Texas
Date of Contract:	1 May 1966
Amount of Contract:	\$624,897
Contract No:	AF 33(657)-16563
Contract Expiration Date:	31 October 1967
Program Manager:	B. B. Leichliter, BR 1-2561 Garland, Texas

ABSTRACT

This report describes the operation of the Uinta Basin Seismological Observatory (UBSO) from 1 February 1967 through 30 April 1967. Modifications and additions to the observatory instrumentation are described, and tests to improve the operations of the observatory are reported. Also discussed is the status of special investigations designed to evaluate and improve the detection capability of the observatory.

CONTENTS

	<u>Page</u>
ABSTRACT	
1. INTRODUCTION	1
1.1 Authority	1
1.2 History	1
2. OPERATION OF UBSO	1
2.1 General	1
2.2 Seismograph operating parameters	3
2.2.1 Standard seismographs	3
2.2.2 Filters for multichannel array processors (MAP)	3
2.2.3 Filters for surface and shallow-buried array summations	3
2.2.4 Filters for vertical array summations	3
2.3 Data channel assignments	3
2.4 Data outages	11
2.5 Commercial power failure	11
2.6 Quarterly phototube amplifier (PTA) linearity and galvanometer damping checks	11
2.7 Lightning storm	11
2.8 Planned change in station procedure	11
2.9 Shipment of data to the seismic data laboratory (SDL)	12
2.10 Quality control	12
2.11 Cooperation with the long range seismic measurements (LRSM) program	14
2.12 Security inspection	14
3. EVALUATE DATA AND PROVIDE MOST EFFECTIVE OBSERVATORY POSSIBLE	14
3.1 Modifications to instrumentation at UBSO	14
3.1.1 Modified 1 kW Power Amplifier, Model 22183	14
3.1.2 Timing System, Model 11880	14
3.2 Additions to instrumentation at UBSO	15
3.2.1 Paper-tape punching machine for preparing routine messages	15
3.2.2 Long-period cable trench	15
4. TRANSMIT DAILY MESSAGES TO THE COAST AND GEODETIC SURVEY	15
5. PUBLISH MONTHLY EARTHQUAKE BULLETIN	16
5.1 Bulletin status	16
5.2 Revised bulletin distribution list	16

CONTENTS, Continued

	<u>Page</u>
6. MAINTAIN UBSO FACILITIES	18
6.1 Air-conditioning system	18
6.2 Scrap cable from the vertical array	18
6.3 Array cleanup	18
6.4 Line power stability	18
7. MAINTAIN UBSO EQUIPMENT	19
7.1 Flooding of Develocorders	19
7.2 S&E Voltage regulator	19
7.3 Ampex tape recorder (tape recorder No. 4)	19
7.4 Magnetic-tape recorder 3	19
7.5 Winch repair	19
8. INSTRUMENT EVALUATION	20
8.1 Evaluation of vertical array	20
8.1.1 Repairs to vertical array	20
8.1.2 Malfunction of DH2 and DH3	20
8.1.3 "G" Measurements on elements of vertical array	20
8.1.4 Evaluation of data recorded by vertical array	21
8.1.5 Planned repairs and modifications to elements of vertical array	21
8.2 Evaluation of underground long-period vault	21
8.2.1 Surface long-period horizontal seismometer	21
8.2.2 New long-period seismometers	21
8.2.3 Long-period noise associated with high wind	21
8.3 Technical assistance and monitor of Sandia's USO	26
9. SPECIAL INVESTIGATIONS	27
9.1 Evaluation of MAP	27
9.1.1 Multifrequency relative amplitude responses	27
9.1.2 Visual S/N comparison	27
9.1.3 Visual noise measurements	27
9.1.4 Noise power spectra	27
9.1.5 Detection capability comparison	28
9.2 Arrival time residual study	28
9.3 Signal classification study	29
9.4 Long-period noise rms levels recorded at TFSO, UBSO, and WMSO	30
9.5 Long-period array investigation	30
9.6 Routine noise measurements	34

CONTENTS, Continued

	<u>Page</u>
10. PROVIDE OBSERVATORY FACILITIES AND ASSISTANCE TO OTHER ORGANIZATIONS	34
10.1 NASA Sonic boom study	34
10.2 Data sent to the University of Utah	34
10.3 Deletion of magnetic tape shipment to C&GS, Albuquerque	34
10.4 Shipment of UBSO daily messages to Colorado School of Mines	34
10.5 Shipment of UBSO daily letter reports to the U. S. Geological Survey	35
10.6 Vistors	35
11. REPORTS	36

ILLUSTRATIONS

<u>Figure</u>		<u>Page</u>
1	Orientation and configuration of UBSO arrays	2
2	Normalized response characteristics of the standard seismographs at UBSO	6
3	Comparison of response of horizontal long-period seismometer in surface vault (NLP5) to responses of long-period seismometers in underground vault under conditions of high wind	22
4	Comparison of responses of broad-response long-period seismographs (ZLP1, NLP1, and ELP1) to responses of narrow-response, long-period seismographs (ZLP2, NLP2, and ELP2) to wind-induced pressure changes	23
5	Comparison of responses of broad-response long-period seismographs (ZLP1, NLP1, and ELP1) to responses of narrow-response, long-period seismographs (ZLP2, NLP2, and ELP2) to wind-induced pressure changes	24
6	Comparison of responses of broad-response, long-period seismographs (ZLP1, NLP1, and ELP1) to responses of narrow-response, long-period seismographs (ZLP2, NLP2, and ELP2) to wind-induced pressure changes	25
7	Normalized frequency responses of TFSO long-period seismographs	31
8	Normalized frequency responses of UBSO long-period seismographs	32
9	Normalized frequency responses of WMSO long-period seismographs	33

TABLES

<u>Table</u>		<u>Page</u>
1	Operating parameters and tolerances of seismographs at UBSO	4
2	Calibration norms and operating tolerances for frequency responses of the standard seismographs at UBSO	5
3	Data channel assignments and normal operating magnifications at UBSO	7
4	Key to the designations used in the data format assignments at UBSO	8
5	Planned 4-week work schedule	13
6	Number of earthquakes reported to the C&GS by UBSO during February, March, and April 1967	17
7	Percent of hypocenters reported in the C&GS "Earthquake Data Report" for which UBSO data were used	17
8	Motor constant ("G") measurements on elements of the vertical array	20
9	Rms values of long-period noise samples recorded at TFSO, UBSO, and WMSO	30

OPERATION OF UBSO - QUARTERLY REPORT NO. 4
1 FEBRUARY 1967 THROUGH 30 APRIL 1967

1. INTRODUCTION

1.1 AUTHORITY

The work described in this report was supported by the Advanced Research Projects Agency, Nuclear Test Detection Office, and was monitored by the Air Force Technical Applications Center (AFTAC), under Contract AF 33(657)-16563. The statement of work for this contract is shown in the appendix.

1.2 HISTORY

The Uinta Basin Seismological Observatory (UBSO) was constructed under Contract AF 33(657)-7185. Site selection and noise surveys were accomplished by Geotech; the final decision on the observatory location was made by AFTAC. Texas Instruments Incorporated (TI) was responsible for the construction of all physical facilities.

Contract AF 33(600)-43486, issued to TI, contained the authority for equipping and operating UBSO. The instrumentation was supplied by Geotech and was installed under the direction of Geotech personnel under subcontract to TI. TI operated the observatory from November 1962 until 1 July 1963. Under Projects VT/1124 and VT/5054, Contract AF 33(657)-12373, Geotech operated UBSO from 1 July 1963 through 30 April 1966.

2. OPERATION OF UBSO

2.1 GENERAL

Data are recorded at UBSO on a 24-hour basis. The observatory is normally manned 8 to 10 hours a day, 5 days a week. On weekends and holidays, a skeleton crew mans the observatory 8 hours a day; however, additional personnel are on call in case of emergency.

The UBSO array configuration is shown in figure 1.

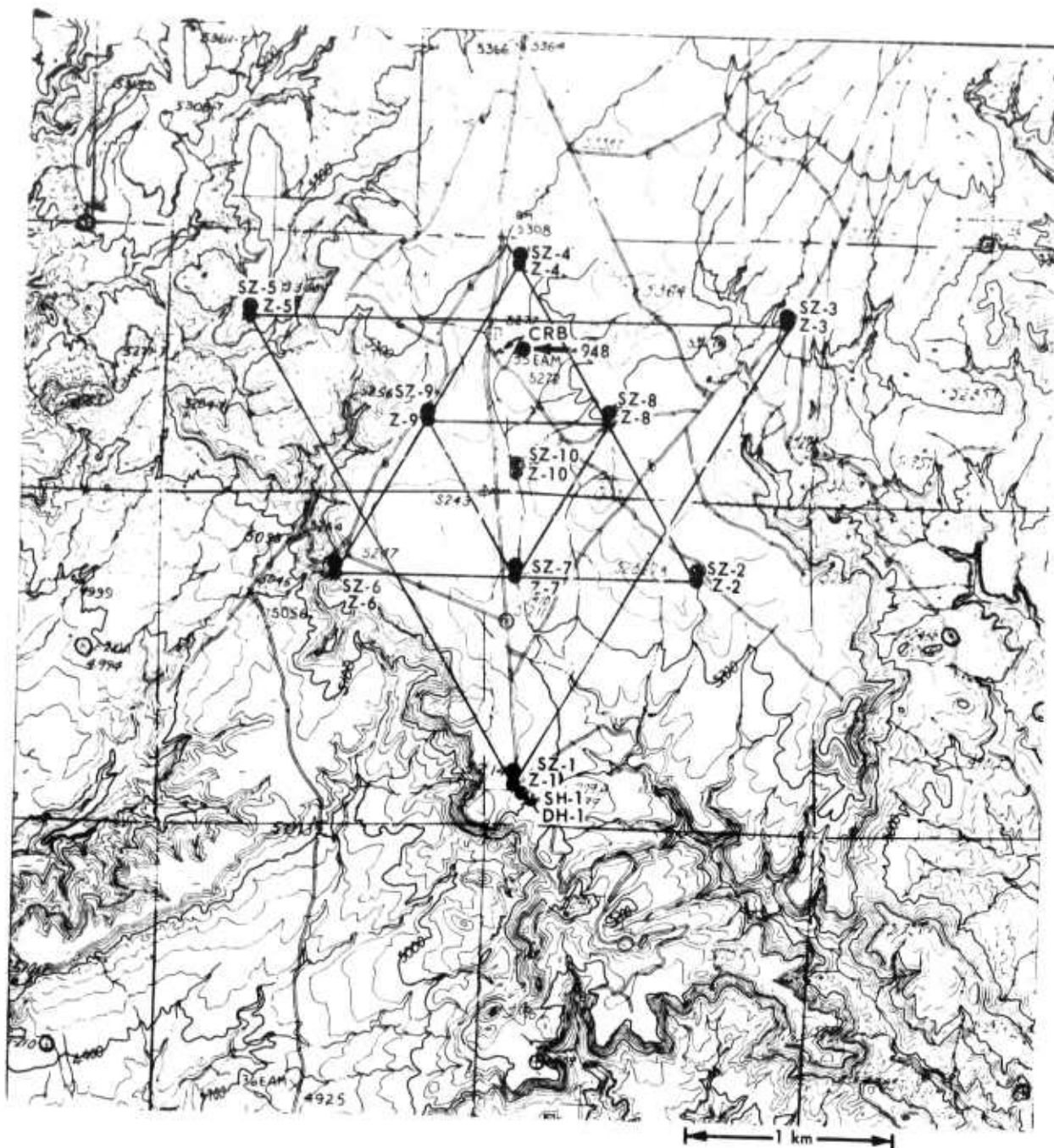


Figure 1. Orientation and configuration of UBSO arrays

G 901

The Project Officer, Captain Frederick D. Munzlinger, visited Geotech's Garland office from 10 April through 12 April to discuss plans for work to be done under Project VT/6705. The UBSO Station Manager, Mr. Frank Seymour, was in Garland for these discussions.

2.2 SEISMOGRAPH OPERATING PARAMETERS

2.2.1 Standard Seismographs

The operating parameters and the tolerances for the standard observatory seismographs are shown in table 1. These parameters are reset, as necessary, when the frequency response of a seismograph is found to be out of tolerance. The frequency response norms and their respective tolerances are shown in table 2. The frequency responses of the UBSO seismographs, as normally operated are shown in figure 2.

2.2.2 Filters for Multichannel Array Processors (MAP)

All MAP channels utilize a band-pass filter with the following settings: a high-cut corner frequency of 3 cps at 6 dB per octave cutoff rate, and a low-cut corner frequency of 1 cps at 12 dB per octave cutoff rate.

2.2.3 Filters for Surface and Shallow-Buried Array Summations

Summations of the ten-element surface array and the ten-element shallow-buried array are each filtered by a band-pass filter with the following settings: A high-cut corner frequency of 3 cps and a low-cut corner frequency of 0.8 cps, both at a cutoff rate of 18 dB per octave.

2.2.4 Filters for Vertical Array Summations

The six elements of the vertical array are summed, and two outputs are recorded. Throughout the reporting period, one of the outputs (ΣDH) was operated as an unfiltered summation, and the second output (ΣDHF) was filtered by a band-pass filter with the following settings: a high-cut corner frequency of 3 cps at a cutoff rate of 24 dB per octave and a low-cut corner frequency of 0.75 cps at a cutoff rate of 36 dB per octave.

2.3 DATA CHANNEL ASSIGNMENTS

On 8 February, Data Group 5032 was established, replacing station time with the appropriate time-code data-management group identifier (TCDMG) on tape recorder 4. The current data-channel assignments and normal operating magnifications for all UBSO data groups are shown in table 3. The key to the designators used in the data-channel assignments is given in table 4.

Table 1. Operating parameters and tolerances of seismographs at UBSO

Seismograph			Operating parameters and tolerances					Filter settings	
System	Comp	Seismometer	T _s	λ _s	T _g	λ _g	σ ²	Bandpass at 3 dB cutoff (sec)	Cut off rate at SP side (dB/oct)
		Type	Model						
SP	Z and H	Johnson-Matheson	7515						
SP	SZ	Geotech	6480	1.25 ±2%	0.51 ±5%	0.33 ±5%	0.65 ±5%	0.1-100	12
SP	Z	UA Benioff	18300	1.25 ±2%	0.51 ±5%	0.33 ±5%	0.65 ±5%	0.1-100	12
IB	Z	Melton	1051	1.0 ±5%	1.0	0.083 ±5%	1.0	-	-
IB	H	Geotech	10012	2.5 ±5%	0.65 ±5%	0.64 ±5%	1.2 ±5%	0.05-100	12
BB	Z	Geotech	8700B	2.5 ±5%	0.65 ±5%	0.64 ±5%	1.2 ±5%	0.05-100	12
BB	H	Geotech	7505	12.5 ±5%	0.485 ±5%	0.64 ±5%	9.0 ±5%	0.05-100	12
LP	Z	Geotech	8700A	12.5 ±5%	0.485	0.64 ±5%	9.0 ±5%	0.05-100	12
LP	F	Geotech	7505A	20.0 ±5%	0.74 ±5%	110 ±10%	0.85 ±10%	0.05-100	12
			8700A	20.0 ±5%	0.74 ±5%	110 ±10%	0.85 ±10%	25-1000	12
								25-1000	12
KEY									
SP	Short period		T _s	Seismometer free period (sec)					
IB	Intermediate band (currently inactive)		T _g	Galvanometer free period (sec)					
BB	Broad band		λ _s	Seismometer damping constant					
LP	Long period		λ _g	Galvanometer damping constant					
UA	Unamplified (i.e., earth powered)		σ ²	Coupling coefficient					

Table 2. Calibration norms and operating tolerances for frequency responses of the standard seismographs at UBSO

SP Vertical 18300 and SP Johnson-Matheson Vertical and Horizontal				LP Vertical and Horizontal ^c			
<u>f</u> (cps)	<u>T</u> (sec)	<u>R. M.</u>	<u>A. T.</u> (±%)	<u>f</u> (cps)	<u>T</u> (sec)	<u>R. M.</u>	<u>A. T.</u> (±%)
0.2	5.0	0.0113	10	0.01	100	0.246	20
0.4	2.5	0.0950	7.5	0.0125	80	0.377	20
0.8	1.25	0.685	5	0.0167	60	0.589	15
1.0	1.0	1.0	-	0.02	50	0.745	15
1.5	0.67	1.52	5	0.025	40	0.899	10
2.0	0.5	1.90	5	0.033	30	1.06	5
3.0	0.33	2.12	7.5	0.04	25	1.0	-
4.0	0.25	1.87	12	0.05	20	0.822	5
6.0	0.167	1.15	20	0.0667	15	0.506	10
8.0	0.125			0.10	10	0.173	20
10.0	0.100			0.143	7	b	a

IB Vertical and Horizontal				BB Vertical and Horizontal			
<u>f</u> (cps)	<u>T</u> (sec)	<u>R. M.</u>	<u>A. T.</u> (±%)	<u>f</u> (cps)	<u>T</u> (sec)	<u>R. M.</u>	<u>A. T.</u> (±%)
0.1	10.0	0.0090	25	0.04	25.0	0.104	20
0.2	5.0	0.068	20	0.06	16.7	0.350	20
0.3	3.3	0.25	15	0.08	12.5	0.775	15
0.4	2.5	0.46	10	0.1	10.0	0.950	10
0.5	2.0	0.64	5	0.2	5.0	1.0	5
0.7	1.43	0.86	5	0.4	2.5	1.0	5
1.0	1.0	1.0	-	0.8	1.25	1.0	-
1.5	0.67	1.04	5	1.6	0.625	1.0	5
2.0	0.5	1.0	10	3.2	0.312	1.0	10
3.0	0.33	0.89	15	6.4	0.156	0.980	15
5.0	0.2	0.66	20				

KEY

- R. M. Relative magnification
A. T. Amplitude tolerance
a Tolerance not established in the period
b Measurements not reliable due to interference from microseismic background noise
c These norms and tolerances apply to the broad-response, long-period system (LP1).

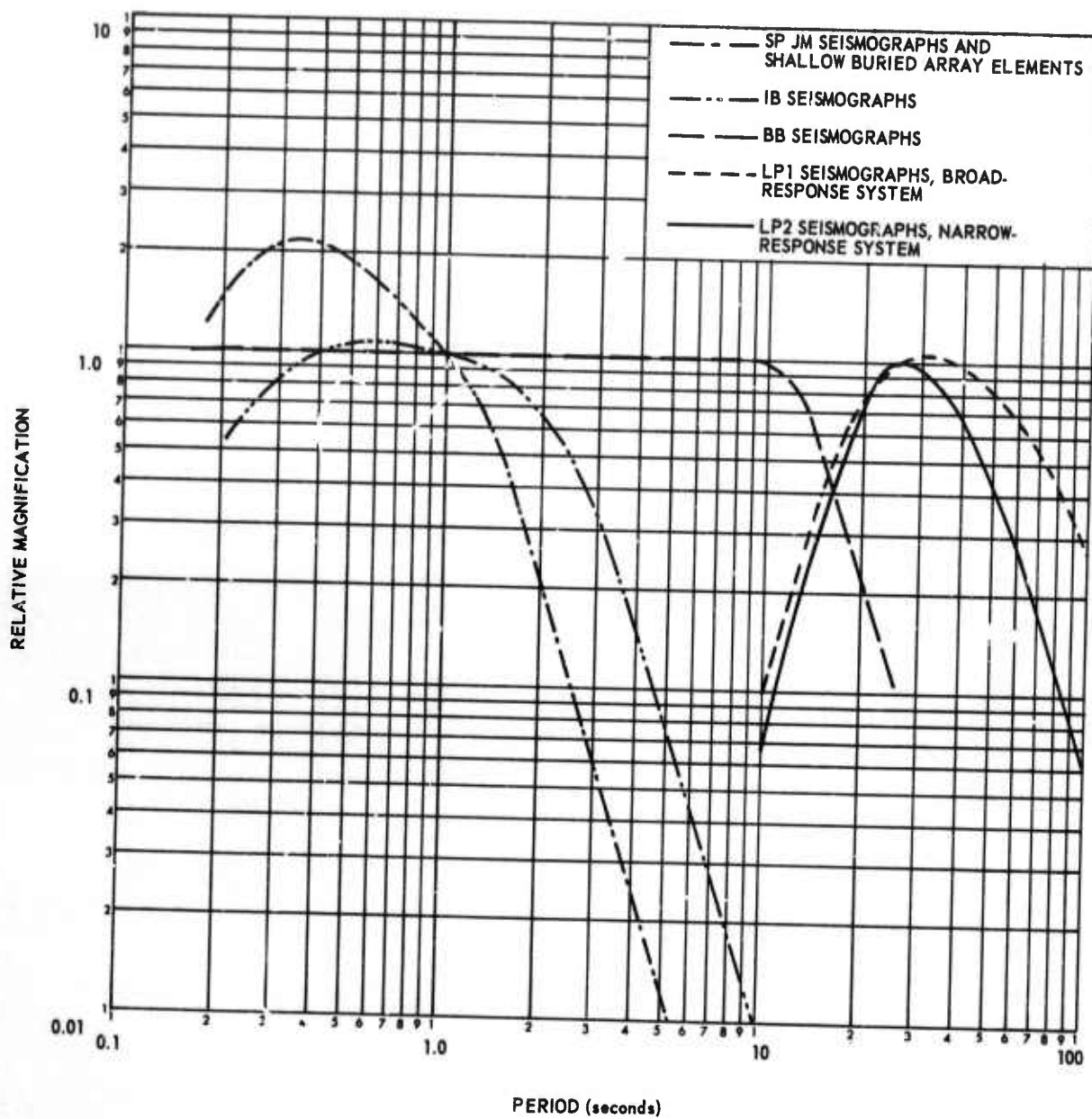


Figure 2. Normalized response characteristics of the standard seismographs at UBSO

G 1438

Table 3. Data channel assignments and normal operating magnifications at UBSO

DEVELOCORDERS

FAST SPEED 30mm/min.			SLOW SPEED 3mm/min.		
DATA GROUP 5044			DATA GROUP 5064		
SP Primary			DATA GROUP 5068		
Channel	Trace	Mag.	Channel	Trace	Mag.
1	V	2K	1	SZ10L	60K
2	SZ1	600K	2	NSPL	60K
3	SZ3	600K	3	ESPL	60K
4	SZ5	600K	4	Z10LL	5K
5	SZ7	600K	5	NSPLL	5K
6	SZ9	600K	6	ESPLL	5K
7	SZ11	600K	7	Z1	600K
8	SZ13	600K	8	Z3	600K
9	SZ15	600K	9	Z5	600K
10	SZ17	600K	10	Z7	600K
11	SZ19	600K	11	Z9	600K
12	SZ21	600K	12	Z11	600K
13	SZ23	600K	13	Z13	600K
14	SZ25	600K	14	Z15	600K
15	SZ27	600K	15	Z17	600K
16	SZ29	600K	16	Z19	600K

DATA GROUP 5044			DATA GROUP 5070		
SP Primary			MAP I		
Channel	Trace	Mag.	Channel	Trace	Mag.
1	V	2K	1	Test	---
2	MS1	0.75 b /mm	2	MCF4	Testing
3	MS2	0.75 b /mm	3	MCF1	Testing
4	DH6	1000K	4	MCF2	Testing
5	DH5	1000K	5	MCF3	Testing
6	DH4	1000K	6	BSS1	Testing
7	DH3	1000K	7	BSS2	Testing
8	DH2	1000K	8	BSS3	Testing
9	DH1	1000K	9	BSS4	Testing
10	EDHF	6000K	10	BSS5	Testing
11	EDH	1500K	11	BSS6	Testing
12	SZ8	500K	12	WV	---
13	USO-SP	---	13	WV	---
14	USO-Time	---	14	WV	---
15	W1	3 mph/mm	15	WV	---
16	WV	---	16	WV	---

DATA GROUP 5066			DATA GROUP 5072		
MAP II			MAP II		
Channel	Trace	Mag.	Channel	Trace	Mag.
1	W1	3 mph/mm	1	Test	---
2	SZ2	300K	2	MCF11	Testing
3	ZLP1	25K	3	MCF12	Testing
4	NLP1	25K	4	MCF13	Testing
5	ELP1	25K	5	MCF14	Testing
6	NLPS	20K	6	MCF15	Testing
7	ZLP2	100K	7	MCF16	Testing
8	NLP2	100K	8	MCF17	Testing
9	ELP2	100K	9	BSSV1	Testing
10	ML1	3.0 b /mm	10	BSSV2	Testing
11	ML2	3.0 b /mm	11	BSSV3	Testing
12	USO-LP	---	12	BSSV4	Testing
13	ZBB	1.0K	13	BSSV5	Testing
14	NBB	1.0K	14	BSSV6	Testing
15	EBB	1.0K	15	EDVS	Testing
16	WV	---	16	WV	---

MAGNETIC TAPE RECORDERS

DATA GROUP 5029			DATA GROUP 5023		
No. 1			No. 2		
Channel	Trace		Channel	Trace	
1	TCDMG		1	TCDMG	
2	DH1		2	ZBB	
3	DH2		3	NBB	
4	DH3		4	EBB	
5	DH4		5	NSP	
6	DH5		6	ESP	
7	Comp.		7	Comp.	
8	DH6		8	ZLP1	
9	EDH		9	NLP1	
10	EDHF		10	ELP1	
11	Z10LL		11	ZLP2	
12	NSPLL		12	NLP2	
13	ESPLL		13	ELP2	
14	WV		14	WV	
	& Voice			& Voice	

DATA GROUP 5025			DATA GROUP 5033		
No. 3			No. 4		
Channel	Trace		Channel	Trace	
1	TCDMG		1	TCDMG	
2	SZ1		2	USOZSP	
3	SZ2		3	USOZLP	
4	SZ3		4	USO Time	
5	SZ4		5	ES	
6	SZ5		6	ISSF	
7	Comp.		7	Comp.	
8	SZ6		8	MCF1	
9	SZ7		9	MCF3	
10	SZ8		10	MCF4	
11	SZ9		11	MCF11	
12	SZ10		12	MCF12	
13	ES		13	MCF13	
14	WV		14	WV	
	& Voice			& Voice	

Table 4. Key to the designations used in the data
format assignments at UBSO

Z	Amplified vertical short-period seismograph from a site identified by a suffix number	WI	Anemometer-wind speed and direction
NSP	Amplified north-south short-period seismograph	WWV	Radio time (WWV, STS, and voice on tape)
ESP	Amplified east-west short-period seismograph	ZBB	Vertical broad-band seismograph
V	Unamplified vertical short-period seismograph	NBB	North-south broad-band seismograph
ZLP1	Vertical long-period seismograph, broad response	EBB	East-west broad-band seismograph
NLP1	North-south long-period seismograph, broad response	ΣS	Summation of Z1 through Z10
ELP1	East-west long-period seismograph, broad response	ΣSF	ΣS filtered
		ΣSS	Summation of SZ1 through SZ10
		ΣSSF	ΣSS filtered
ZLP2	Vertical long-period seismograph, narrow response	DH1	Vertical-array element at 8895 feet
NLP2	North-south long-period seismograph, narrow response	DH2	Vertical-array element at 7903 feet
ELP2	East-west long-period seismograph, narrow response	DH3	Vertical-array element at 6910 feet
		DH4	Vertical-array element at 5894 feet
NLPS	North-south long-period seismograph, broad response (operated in surface tank)	DH5	Vertical-array element at 4901 feet
MS1	Short-period microbarograph (inside LP vault)	DH6	Vertical-array element at 3907 feet
MS2	Short-period microbarograph (outside LP vault)	ΣDH	Summation of DH1 through DH6

Table 4. Continued

Σ DHF	Σ DH filtered	MCF12	Multichannel filter: ∞ velocity signal and theoretical noise model using SZ1 - SZ10 and DH1 - DH6
ML1	Long-period microbarograph (inside LP vault)		
ML2	Long-period microbarograph (outside LP vault)	MCF13	Multichannel filter: ∞ velocity signal and theoretical noise model using DH1 - DH6
MCF3	Multichannel filter: 8.1 ∞ km/sec velocity signal and measured noise correlations (not including road noise) using Z1 - Z10	MCF14	Deghost filter: up-going ∞ velocity P-wave signal and theoretical noise model using DH1, DH3, and DH5
Test	Test instrumentation		
Comp	Compensation	MCF15	Deghost filter: down-going ∞ velocity P-wave signal and theoretical noise model using DH1, DH3, and DH5
Mag	Magnification (see note)		
TCMDG	Time code management data group	BSS1	Beam-steered summation: 8.1 km/sec signal from azimuth of 0°, using Z1 - Z10
USO-SP	Unmanned seismological observatory short-period seismograph	BSS2	Beam-steered summation: 8.1 km/sec signal from azimuth of 60°, using Z1 - Z10
USO-LP	Unmanned seismological observatory long-period seismograph	BSS3	Beam-steered summation: 8.1 km/sec signal from azimuth of 120°, using Z1 - Z10
MCF1	Multichannel filter: ∞ velocity signal and measured noise correlations (not including road noise) using Z1 - Z10	BSS4	Beam-steered summation: 8.1 km/sec signal from azimuth of 180°, using Z1 - Z10
MCF4	Multichannel filter: ∞ velocity signal and measured noise correlations (including road noise), using Z1 - Z10	BSS5	Beam-steered summation: 8.1 km/sec signal from azimuth of 240°, using Z1 - Z10

Table 4. Continued

BSS6	Beam-steered summation: 8.1 km/sec signal from azimuth of 300°, using Z1 - Z10	MCF16	Deghost filter: up-going ∞ velocity P-wave signal and theoretical noise model, using DH2, DH4, and DH6
ΣSBS	Summation of Z1 - Z10, with MAP band-pass filter	MCF17	Deghost filter: down-going ∞ velocity P-wave signal and theoretical noise model, using DH2, DH4, and DH6
MCF11	Multichannel filter: ∞ velocity signal and measured noise correlations (not including road noise), using SZ1 - SZ10	BSSV1	Beam-steered summation: up-going ∞ velocity P-wave using DH1 - DH6
BSSV2	Beam-steered summation: up-going 8.1 km/sec P-wave using DH1 - DH6	BSSV6	Beam-steered summation: down-going 8.1 km/sec S-wave, using DH1 - DH6
BSSV3	Beam-steered summation: up-going 8.1 km/sec S-wave, using DH1 - DH6	ΣDVS	Summation of SZ1 - SZ10 and DH1 - DH6, with MAP band-pass filter
BSSV4	Beam-steered summation: down-going ∞ velocity P-wave, using DH1 - DH6	<u>NOTE</u> Magnification of: Short-period measured at 1 cps Broad-band measured at 0.8 cps Long-period measured at 0.04 cps MCF measured at 1 cps BSS measured at 1 cps	
BSSV5	Beam-steered summation: down-going 8.1 km/sec P-wave, using DH1 - DH6		

2.4 DATA OUTAGES

On 27 March, 10 hours and 40 minutes of short-period primary data were lost because of a malfunctioning peristaltic pump in the Develocorder.

On 12 April, the Develocorder blower motor jammed, which opened the line power fuse to Develocorder 5, and resulted in a loss of approximately 11 hours of MAP II data.

2.5 COMMERCIAL POWER FAILURE

On 31 March, commercial power to UBSO failed for 40 minutes. All standby systems functioned normally during the power outage.

2.6 QUARTERLY PHOTOTUBE AMPLIFIER (PTA) LINEARITY AND GALVANOMETER DAMPING CHECKS

The quarterly PTA linearity and galvanometer damping checks were completed on 15 April. Any units found to be out of tolerance were adjusted to bring them within tolerance.

2.7 LIGHTNING STORM

A lightning storm occurred at UBSO on 19 March. Heavy spiking on DH6 was traced to a leaking spiral-four hock. The hock was dried and the system was returned to operation. On the same day, DH4 became inoperative because of a high-resistance short in the protector circuits at the wellhead. The data lines were transferred to a different circuit in the protector box and the system was returned to operation.

2.8 PLANNED CHANGE IN STATION PROCEDURE

In April, the following changes in UBSO routine operational procedures were recommended and approved by the Project Officer.

1330Z: Shut down and service secondary Develocorder. This Develocorder will be ready to record primary data by 1400Z.

Shut down, service, and return to operation, Develocorders 4, 5, and 6.

1400Z: Switch primary data to the standby Develocorder, then shut down and service the previous, primary Develocorder. When this Develocorder is in operation, switch secondary data to this camera.

1430Z: Begin routine daily calibrations. This new calibration schedule will not conflict with the calibration schedules of the other observatories.

All other station routines will remain unchanged. A typical 4-week work schedule is shown in table 5. Note that there will be two late analyst shifts and one late technician shift on Thursday, Friday, Saturday, and Sunday.

With this schedule, station personnel will be able to check the Develocorders for proper operation during the first 10 hours after film change. In addition, the analysts will have gains available for the first 14 hours of each run while reading the seismograms. The only disadvantage to the new procedure will be that two logs per run will be required for primary and secondary data, since any one run will be recorded partly on Develocorder 1 and partly on Develocorder 2.

We plan to begin the new schedule about 5 May.

2.9 SHIPMENT OF DATA TO THE SEISMIC DATA LABORATORY (SDL)

Magnetic-tape seismograms are shipped to SDL with the regular Long-Range Seismic Measurements (LRSM) Program data shipment about 15 days after the end of the month during which they were recorded. The seismograms from magnetic-tape recorders 1, 2, and 3 recorded at UBSO through 31 March and magnetic-tape recorder 4 seismograms recorded through 28 February have been shipped to SDL.

All 16-millimeter film seismograms recorded at UBSO through 31 January were sent to SDL. More recent films are currently held in Garland for special studies.

2.10 QUALITY CONTROL

Quality control checks were made on randomly selected runs of all recordings from the observatory. Results of the checks were sent to the observatory for corrective action as necessary.

Table 5. Planned 4-week work schedule

	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F
	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
Tech A	L	L	E	E	E	E	E	L	L	E	E	E	E	E	E	E	E	E	E	E	E
Tech B	L	L	E	E	E	E	E	L	L	E	E	E	E	E	E	E	E	E	E	E	E
Tech C	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
Tech D	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Analyst A	E	E	E	L	L	L	L	E	E	E	L	L	L	L	L	L	L	L	L	L	L
Analyst B	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Analyst C	L	L	E	E	E	E	E	L	L	E	E	E	E	E	L	L	E	E	E	E	E
Analyst D	L	L	E	E	E	E	E	L	L	E	E	E	E	E	L	L	E	E	E	E	E
Sta. Manager	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E

E: Early shift 1330Z - 2200Z 7:30 AM - 4:00 PM MDT

L: Late shift 1630Z - 0100Z 10:30 AM - 7:00 PM MDT

2.11 COOPERATION WITH THE LONG RANGE SEISMIC MEASUREMENTS (LRSM) PROGRAM

UBSO began sending copies of the daily message to Mr. Rudy Weisbrich, Geotech LRSM Group, on 10 April for use in conjunction with a special LRSM project.

2.12 SECURITY INSPECTION

Mr. William J. Robertson, Industrial Security Specialist, conducted a security inspection of UBSO on 20 April. All observatory security procedures were found to be in order.

A copy of the Geotech Standard Practices Procedures and a UBSO addendum were mailed to Mr. Robertson on 9 February.

3. EVALUATE DATA AND PROVIDE MOST EFFECTIVE OBSERVATORY POSSIBLE

3.1 MODIFICATIONS TO INSTRUMENTATION AT UBSO

3.1.1 Modified 1 kW Power Amplifier, Model 22183

The modified 1 kW Power Amplifier, Model 22183, continued to fail repeatedly during this reporting period. Most, but not all of the failures occurred during adjustments to the timing system. In March, UBSO personnel installed a switch to allow the power amplifier to be started with no load, and then to switch the load to the amplifier after the unit is running. This modification was only partially successful. On 23 April, the power amplifier failed and would not restart. The trouble was traced to the output power transistors, which had failed. When the unit was restarted, it was discovered that it was not necessary to reset the protector circuit, indicating that the protection circuit may be inoperative. We are awaiting the outcome of laboratory tests of newly designed modifications of the amplifier.

3.1.2 Timing System, Model 11880

From 14 April until the end of the reporting period, the Timing System, Model 11880, behaved erratically. On some occasions, the timing system skipped several hundred milliseconds, and at other times the system exhibited a very fast drift rate. In our opinion, malfunctioning of a phasing transformer in the strobe unit is the cause of this erratic behavior.

On 24 April, the spare phasing transformer was sent to our Garland laboratory to be installed in our spare strobe unit. The modified strobe unit is scheduled to be returned to UBSO by early May.

3.2 ADDITIONS TO INSTRUMENTATION AT UBSO

3.2.1 Paper-Tape Punching Machine for Preparing Routine Messages

In order to reduce the number of errors in messages transmitted to the Coast and Geodetic Survey, we investigated the feasibility of preparing the message on punched paper tape at UBSO so that the Western Union Agent in Vernal could transmit the message without an intermediate manual transcription. The Western Union Regional Supervisor in Salt Lake City, Mr. Walter May, agreed to install the necessary punched paper-tape reading equipment in Western Union's Vernal office if we would acquire the paper tape punching machine to be installed at UBSO. We sent a list of the necessary equipment to the General Services Administration (GSA) office in Salt Lake City so that they could search their inventory for the needed surplus equipment. The GSA informed us that it was unlikely that we would find the equipment we need in their surplus inventory because military agencies screen all surplus equipment lists before the equipment is transferred to GSA. The GSA recommended that we submit our request through our Project Officer. On 10 April, we submitted our request to the Project Officer. As of the end of the reporting period, Western Union had installed the necessary paper-tape reading machine in its Vernal office, and we were awaiting further word concerning our request for surplus paper tape punching equipment for installation at UBSO.

3.2.2 Long-Period Cable Trench

In April, a cable trench from the central recording building to the 50-foot underground long-period vault was dug by a local contractor. UBSO personnel laid 4 lengths of multiconductor cable and 2 lengths of spiral-four cable in the trench and backfilled the excavation. The cables were not connected because we expect to ship the new advanced long-period seismometers to UBSO during the first week in May.

4. TRANSMIT DAILY MESSAGES TO THE COAST AND GEODETIC SURVEY

The arrival time, period, and amplitude measurements for events recorded at UBSO were reported daily to the Director of the Coast and Geodetic Survey (C&GS) in Washington, D. C. The number of events, by type,

reported by UBSO during each month in this reporting period is shown in table 6. The total number of events recorded by the observatory, the number of epicenters determined by the C&GS and reported in the "Earthquake Data Report," and the percent of the hypocenters in which UBSO data were utilized are given in table 7 for November and December 1966. Lists of more recent epicenters have not been completed by the C&GS.

UBSO received permission of the Project Officer to send the daily message to the C&GS on the day following the date the data were recorded, if necessary. As of the end of the reporting period, it has not been necessary to delay the message transmittal until the following day.

5. PUBLISH MONTHLY EARTHQUAKE BULLETIN

5.1 BULLETIN STATUS

Data from UBSO were combined with data from BMSO, CPSO, TFSO, and WMSO and published in a multistation earthquake bulletin. The bulletins for September, October, November, and December 1966 were published and distributed during the reporting period. The January 1967 data were received on 20 April with many errors caused by computer malfunction. Publication of the January bulletin was therefore delayed, awaiting reprocessing of the data. Raw data for February and March were key-punched, transcribed onto magnetic tape, and sent to SDL for processing. Key punching of the April raw data was about 25 percent complete at the end of the reporting period.

5.2 REVISED BULLETIN DISTRIBUTION LIST

In order to determine the general uses being made of observatory bulletin data and to update our bulletin distribution list, a questionnaire was sent in early January 1967 to each of the 73 recipients of the five-station earthquake bulletin. To date, 55 replies have been received. Of these, two respondents indicated that they no longer wish to receive the bulletin and 21 indicated a change of address. Thirty of the respondents indicated they had used bulletin data in past studies, 32 are using bulletin data in present studies, and 37 plan to use bulletin data in future studies.

Table 6. Number of earthquakes reported to the C&GS
during February, March, and April 1967

	<u>Local</u>	<u>Near Regional</u>	<u>Regional</u>	<u>Teleseismic</u>	<u>Total</u>
February	35	366	25	1139	1565
March	25	342	30	1351	1748
April	22	444	29	1188	1683

Table 7. Percentage of hypocenters reported to the C&GS
"Earthquake Data Report" for which UBSO data were used

	<u>Events reported by UBSO</u>	<u>Hypocenters reported by C&GS</u>	<u>Percentage of C&GS events utilizing UBSO data</u>
November 1966	1631	365	73.5
December 1966	1584	320	71.3

6. MAINTAIN UBSO FACILITIES

6.1 AIR-CONDITIONING SYSTEM

The Amperite time-delay relay in the air-conditioning system exploded on 5 April, destroying the resistor and capacitor in the unit. Because we had no replacements, UBSO personnel bypassed the relay. The condenser fan is presently running continuously, regardless of the demand for cooling.

The air-conditioning system at UBSO is presently overloaded because of increased heat dissipation caused by equipment added since installation of the observatory and because of inadequacies in the initial design of the system. Therefore, modifications to the air-conditioning system are necessary to assure reliable operation of the observatory. An estimate for needed modifications and repairs was obtained from Automatic Systems Co., Provo, Utah, in March. Approval of the Project Officer to have the recommended work done was received on 24 April. We expect that installation will be started about 10 May.

6.2 SCRAP CABLE FROM THE VERTICAL ARRAY

An inventory of scrap cable from the vertical array was taken on 22 March. There are 11 coils of cable ranging in length from 500 to 700 feet and 8 coils that are made up of short pieces and junk cable.

6.3 ARRAY CLEANUP

On 27 and 28 March, UBSO personnel collected all empty spiral-four reels in the array area and stored them. While the backhoe was on site to dig the long-period cable trench, we dug a new garbage pit, spread the gravel in the parking lot, and installed a new culvert in the compound driveway.

6.4 LINE POWER STABILITY

On 3 April, Moon Lake Electric Association installed a capacitor across the power lines to the observatory in an attempt to eliminate voltage fluctuations. This addition did not improve the stability of the line power.

7. MAINTAIN UBSO EQUIPMENT

7.1 FLOODING OF DEVELOCORDERS

Two methods of controlling the slime buildup in the Develocorders have been tested during this reporting period. Develocorders 2 and 4 were treated with Dowicide-G, and Develocorders 1, 3, and 5 were treated with Algi-Go tablets. Develocorder 6 was not treated, to serve as a control. Both the Dowicide-G and the Algi-Go tablets proved to be highly effective in reducing the rate of slime buildup. However, on several occasions, the Algi-Go tablets clogged the drain valve from the supply tank. The tablets were put in tobacco sacks to control the sediment. No Develocorder floods due to slime buildup occurred during the last month of this reporting period.

7.2 S&E VOLTAGE REGULATOR

The S&E voltage regulator became inoperative on 28 March. The trouble was traced to a blown diode. No data were lost as a result of this failure.

7.3 AMPEX TAPE RECORDER (Tape Recorder No. 4)

A new set of record and playback heads for the Ampex tape recorder was received and installed on 19 April. The old set of heads was returned to Garland the same day. The new heads have greatly improved the quality of the seismograms recorded by this tape recorder; however, there is still some buckling of the tape as it passes over the capstan drive roller.

7.4 MAGNETIC-TAPE RECORDER 3

Magnetic-tape recorder 3 was found inoperative on 22 April. Inspection of the unit disclosed that the cooling fan for the top bank of oscillators was running erratically. A temporary cooling system was improvised to serve until a new fan can be obtained. On 23 April, magnetic-tape recorder 3 became inoperative again. The trouble was traced to a bad transistor in the power supply to the top bank of oscillators.

7.5 WINCH REPAIR

In preparation for the repair operation on the vertical array, scheduled for mid-May, both winches were inspected and checked for proper operation. The throw-out bearing arm on the small winch was found to be broken. The entire clutch assembly was replaced with the spare unit.

8. INSTRUMENT EVALUATION

8.1 EVALUATION OF VERTICAL ARRAY

8.1.1 Repairs to Vertical Array

On 2 April, DH1 became inoperative. Two sections of spiral-four cable were found to be shorted and were replaced. On 4 April, DH4 became inoperative. The trouble was traced to the fuse box at the winch, where a terminal block had come loose and shorted the fuse. Repairs were made and the system returned to operation.

8.1.2 Malfunction of DH2 and DH3

The second and third deepest elements (DH2 and DH3) of the vertical array continued to drift to the stops during this reporting period. The second deepest element (DH2) became progressively more unreliable; consequently, on 13 March, recording of the output of DH2 was terminated. Therefore, subsequent to 13 March, those MAP II channels which use data from DH2 were not operating as programmed.

8.1.3 "G" Measurements on Elements of Vertical Array

Motor constant ("G") measurements performed on elements of the vertical array during the reporting period are listed in table 8. The weight-lift unit in DH2 was inoperative throughout the reporting period, making "G" measurements on this seismometer impossible.

Table 8. Motor constant ("G") measurements on
elements of the vertical array

	<u>12 Feb</u>	<u>4 March</u>	<u>12 March</u>	<u>2 April</u>	<u>15 April</u>
DH1	0.646	0.645	0.662	0.653	0.677
DH2	-----	-----	-----	-----	-----
DH3	0.256	0.267	0.244	0.255	0.244
DH4	0.708	0.724	0.722	0.702	0.710
DH5	0.603	0.606	0.607	0.592	0.607
DH6	0.619	0.606	0.612	0.599	0.620

8.1.4 Evaluation of Data Recorded by Vertical Array

Power spectra for each element and coherences for each pair of elements of the vertical array were computed for one signal and one noise sample during the reporting period. Evaluation of these data was in progress at the end of the reporting period.

8.1.5 Planned Repairs and Modifications to Elements of Vertical Array

If the vertical array is to become an effective system, it will be necessary to pull the array from the deep hole and repair the seismometers. In addition, the frequency responses of the elements of the vertical array, as presently operated, are far from optimum.

We plan to remove the vertical array from the deep hole about the middle of May. We will make necessary repairs to the elements of the array and adjust their frequency responses to provide greater attenuation of both the high-frequency noise and low-frequency microseisms which currently limit the capability of the vertical array. When repairs and adjustments are completed, we will reinstall the vertical array in the deep hole and operate the system routinely.

8.2 EVALUATION OF UNDERGROUND LONG-PERIOD VAULT

8.2.1 Surface Long-Period Horizontal Seismometer

Recording of the output of the long-period horizontal seismometer (NLPS) in the surface vault adjacent to the 50-foot long-period vault was terminated on 24 February in preparation for the installation of the new advanced long-period seismometers in the underground vault.

8.2.2 New Long-Period Seismometers

The 1 vertical and 2 horizontal advanced long-period seismometers to be installed in the 50-foot underground vault were shipped to UBSO from Garland on 28 April.

8.2.3 Long-Period Noise Associated with High Wind

Examples of noise recorded by the long-period seismographs during periods of high wind are presented in figures 3 through 6. Figure 3 shows a comparison of the response of the surface long-period horizontal seismograph (NLPS) with the responses of the long-period horizontal seismographs (NLP1 and NLP2) located in the underground vault to pressure changes associated with high wind. The NLPS seismograph shows a much greater response to wind-induced pressure changes than do either NLP1 or NLP2.

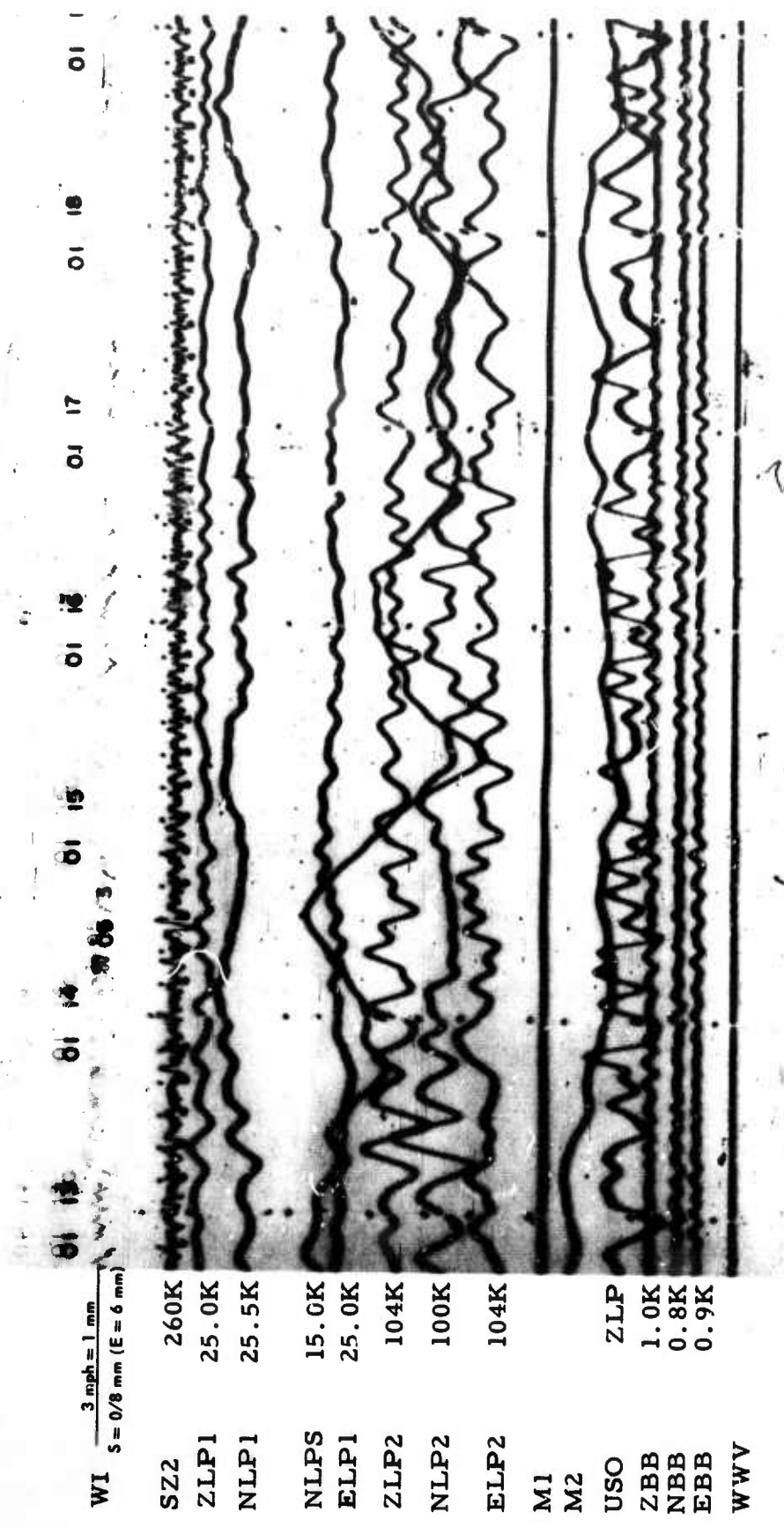


Figure 3. Comparison of response of horizontal long-period seismometer in surface vault (NLP2) to responses of long-period seismometers in underground vault under conditions of high wind.
(X10 enlargement of 16 millimeter film)

UBSO
22 February 1967
Run 053
Data Group 5066

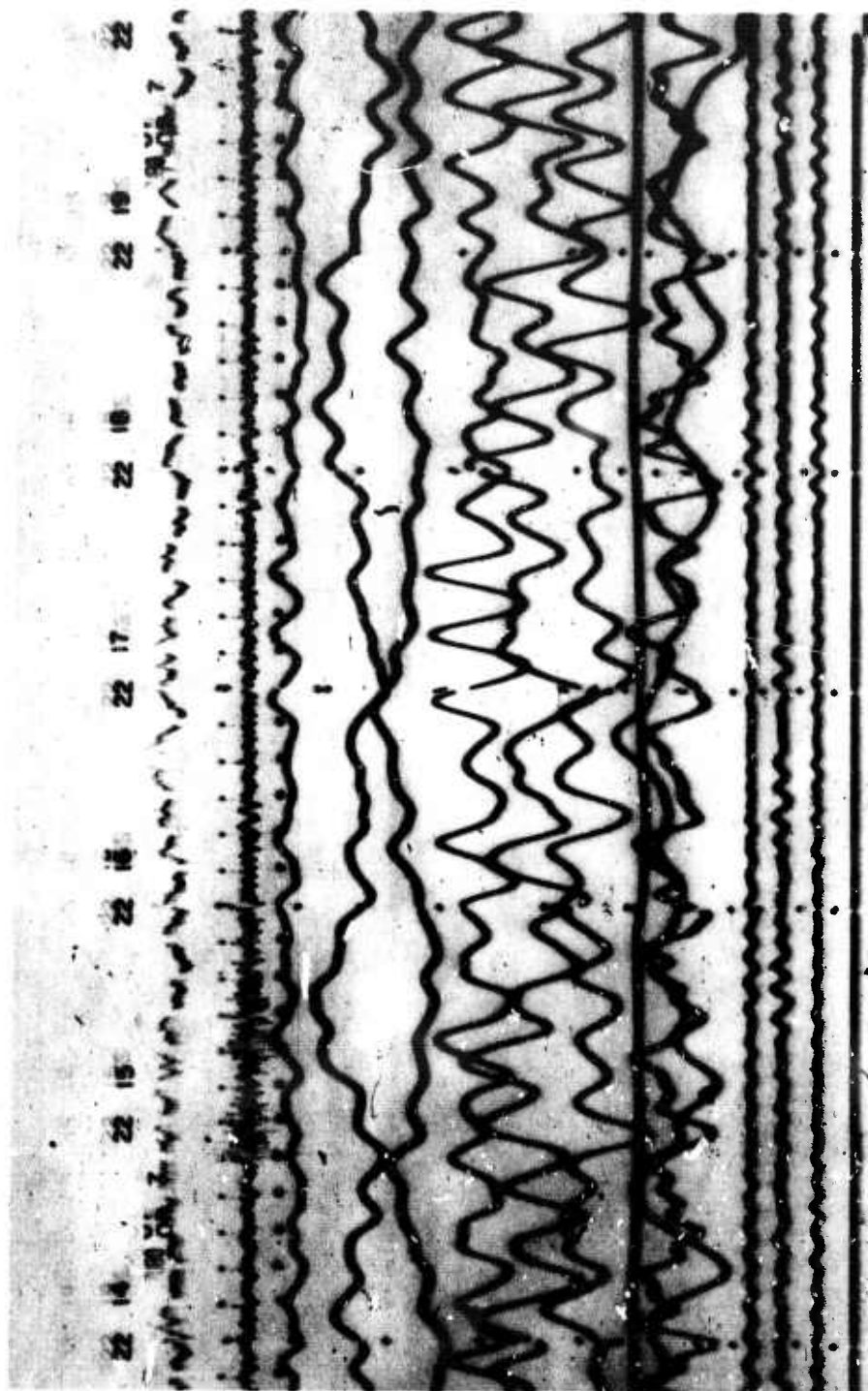


Figure 4. Comparison of responses of broad-response, long-period seismographs (ZLP1, NLP1, and ELP1) to responses of narrow-response, long-period seismographs (ZLP2, NLP2, and ELP2) to wind-induced pressure changes. (X10 enlargement of 16 millimeter film)

WI	$\frac{3 \text{ mph} = 1 \text{ mm}}{5 = 0.8 \text{ mm (E = 6 mm)}}$	
SZ2	250K	
ZLP1	24.5K	
ELP1	25.5K	
NLP1	24.5K	
ZLP2	100K	
NLP2	103K	
ELP2	105K	
ML2	3.68	$\frac{\text{mm}}{\mu\text{b}}$
ML1	3.24	$\frac{\text{mm}}{\mu\text{b}}$
USO	ZLP	$\frac{\text{mm}}{\text{mm}}$
ZBB	0.9K	
NBB	1.2K	
EBB	1.0K	
WWV		

UBSO
28 March 1967
Run 087
Data Group 5074

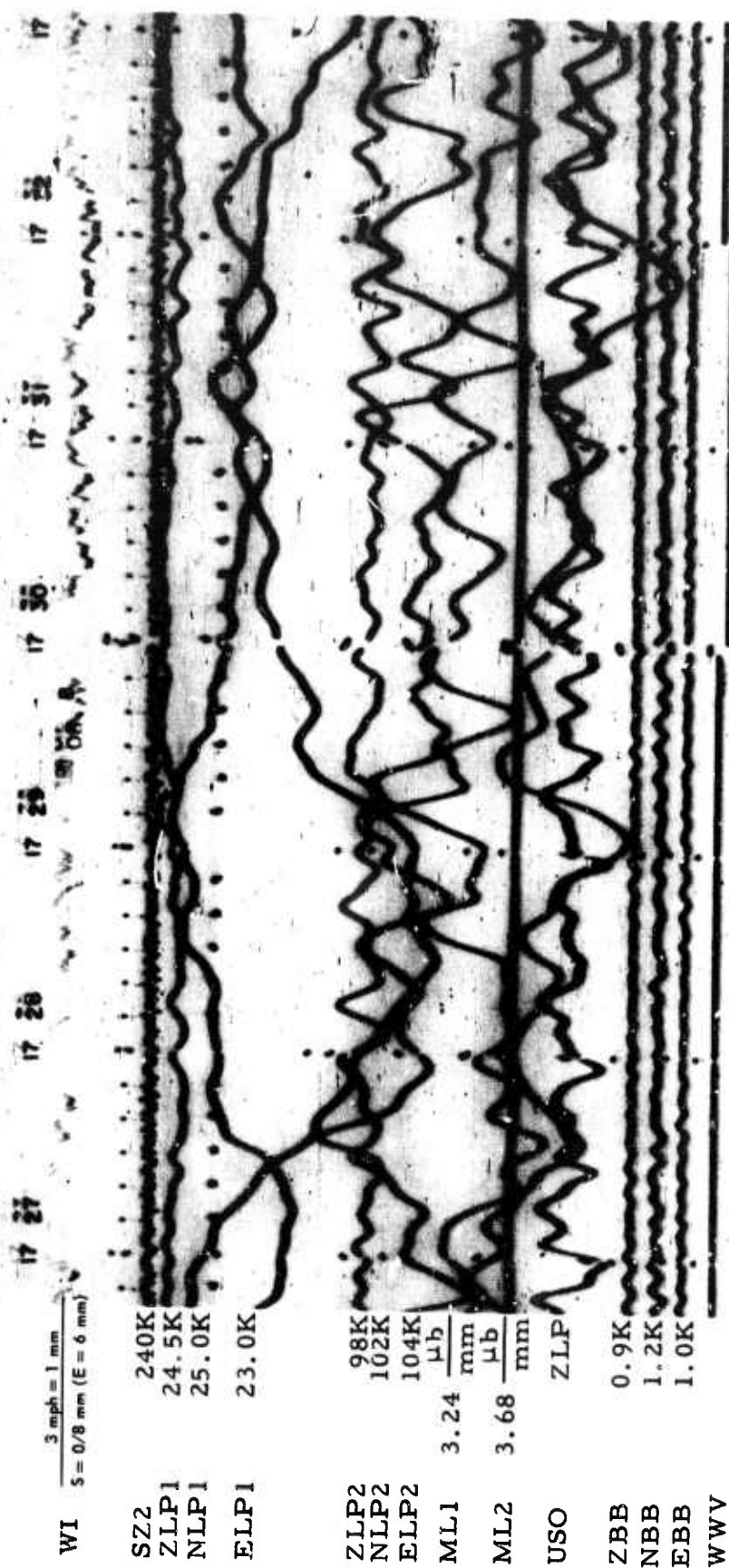


Figure 5. Comparison of responses of broad-response, long-period seismographs (ZLP1, NLP1, and ELP1) to responses of narrow-response, long-period seismographs (ZLP2, NLP2, and ELP2) to wind-induced pressure changes. (X10 enlargement of 16 millimeter film)

UBSO
29 March 1967
Run 088
Data Group 5074

WI $\frac{3 \text{ mph} = 1 \text{ mm}}{S = 0.78 \text{ mm} (E = 6 \text{ mm})}$

SZ2	250K
ZLP1	25.5K
NLP1	26.0K
ELP1	22.5K
ZLP2	98K
NLP2	96K
ELP2	103K
ML1	$\frac{3.32 \text{ } \mu\text{b}}{\text{mm}}$
ML2	$\frac{3.68 \text{ } \mu\text{b}}{\text{mm}}$
USO	ZLP
ZBB	1.1K
NBB	1.0K
EBB	0.7K
WWV	

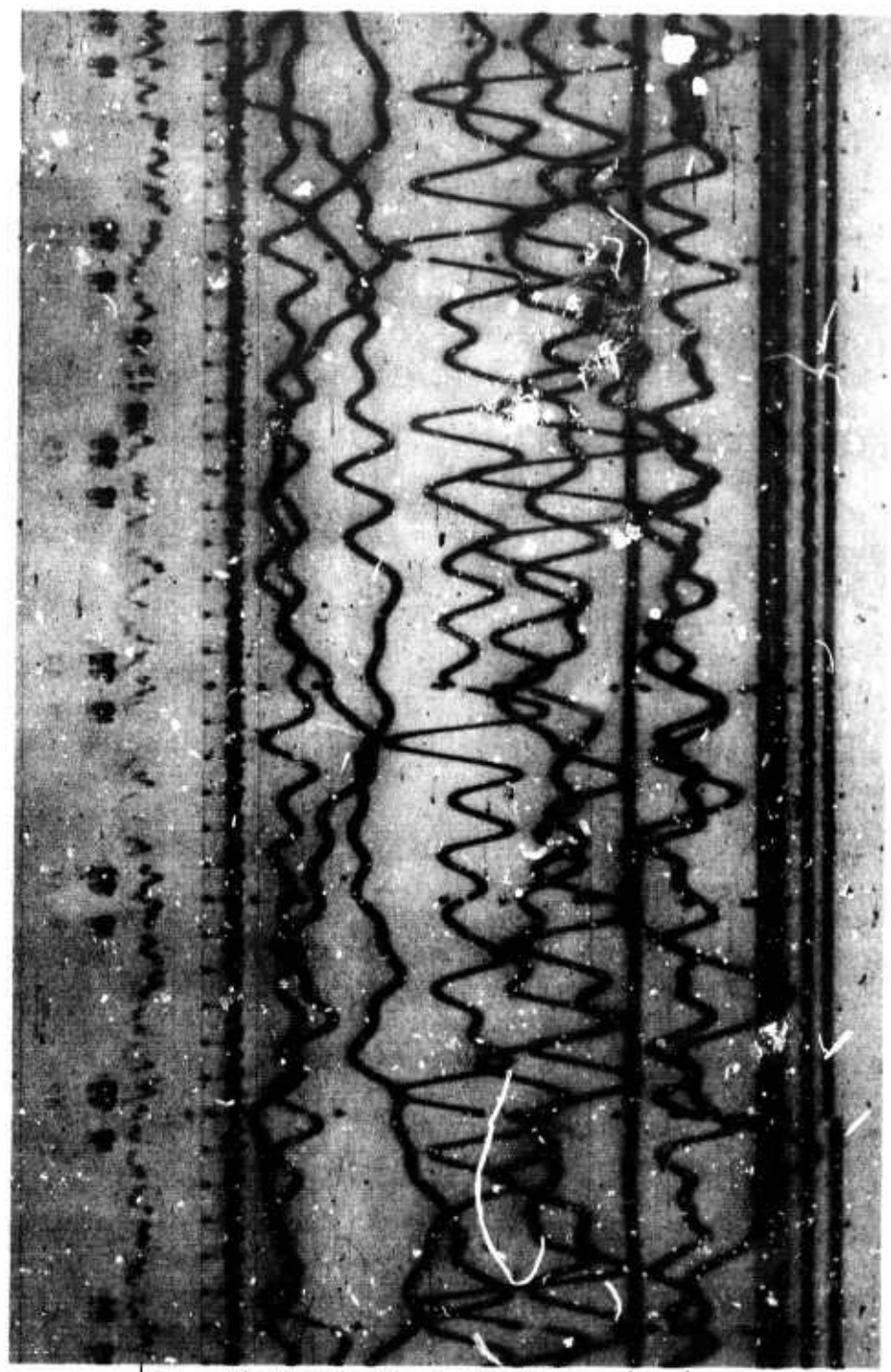


Figure 6. Comparison of responses of broad-response, long-period seismographs (ZLP1, NLP1, and ELP1) to responses of narrow-response, long-period seismographs (ZLP2, NLP2, and ELP2) to wind-induced pressure change. (X10 enlargement of 16-millimeter film)

UBSC
30 April 1967
Run 120
Data Group 5074

Note that NLPS was operating at a gain of only 15K compared to 25.5K for NLP1 and 100K for NLP2.

Figures 4 through 6 show a comparison of the responses of the broad-response seismographs (ZLP1, NLP1, and ELP1) to the responses of the narrow-response seismographs (ZLP2, NLP2, and ELP2) to wind-induced pressure changes. In all cases, the narrow-response seismographs are much less noisy than are the broad-response systems, and the vertical seismographs of each system are much less noisy than are the horizontal seismographs of the corresponding system.

8.3 TECHNICAL ASSISTANCE AND MONITOR OF SANDIA'S USO

Monitoring of the Sandia Unmanned Seismological Observatory (USO) continued throughout the reporting period. From 21 February to 23 March, the USO-East Short-Period (ESP) seismograph operated with fluctuating magnification and with no indication of the changing magnification being given by the automatic gain control (AGC) code. Sandia representatives replaced the amplifier in the USO-ESP seismograph on 23 March. On 24 March, the USO-ESP seismograph became intermittently inoperative. On 26 March, all USO seismographs became inoperative, exhibiting large dc offsets. Sandia personnel arrived at UBSO on 28 March and discovered that their tape recorder was inoperative because of a blown fuse. The fuse was replaced and the tape recorder returned to operation. At this time, Sandia personnel informed us that the operational problems experienced by the USO-ESP were not evident on the USO magnetic-tape seismograms, indicating that the intermittent short causing erratic operation of USO-ESP is located in the line from the USO tape recorder to the Develocorder. Efforts by UBSO personnel to locate the source of the trouble included interchanging the output isolation amplifiers of the USO-ESP and USO-time channels, replacing the data control module 5 which is used for the USO-ESP and USO-time channels, interchanging the data lines of the USO-ESP and USO-time channels, and completely interchanging the circuitry of the USO-ESP and USO-time channels from the USO junction box to the Develocorder galvanometers. The USO-ESP continued to perform erratically throughout all of these tests. Because of the results of these tests and because the USO-ESP channel is being recorded properly on the USO tape recorder, the short must be located between the USO tape recorder and the junction box.

Sandia personnel were notified of the results of the tests; they plan to return to UBSO on 2 May.

9. SPECIAL INVESTIGATIONS

9.1 EVALUATION OF MAP

9.1.1 Multifrequency Relative Amplitude Responses

Multifrequency relative-amplitude responses were run on (multichannel filters) MCF1, MCF3, and MCF4 of MAP I in March. To assure accuracy of the measurements, a frequency counter was used to set the frequency being applied, and measurements were made from a Develocorder record obtained with all traces removed from the Develocorder except the trace representing the output of the MCF being calibrated. A total of 60 man-hours was required to calibrate these three channels of MAP I. Numerous values of the relative amplitudes deviated from the corresponding theoretical values by as much as 20 percent, and a few values deviated from the theoretical values by as much as 50 percent. The cause of these large deviations had not been determined at the end of the reporting period.

9.1.2 Visual S/N Comparison

A comparison of signal-to-noise ratio (S/N), based on visual measurements of signal and noise amplitudes has been made for 10 MAP systems together with SZ10 and Σ SSF for approximately 100 signals. Interpretation of these data was in progress at the end of the reporting period.

9.1.3 Visual Noise Measurements

Visual noise measurements are being made for 10 MAP systems, using the same sampling and measuring techniques that are used for the routine noise measurements from the standard UBSO seismograms. Measurements for 1 month's data had been completed at the end of the reporting period.

9.1.4 Noise Power Spectra

Power spectral density estimates for samples of noise recorded by the 6 MAP systems being recorded on magnetic tape (MCF's 4, 1, and 3 from MAP I, MCF's 11, 12, and 13 from MAP II) are being computed. Samples of 149-second duration have been selected from four conditions of noise, as follows:

- a. Low microseismic noise without road noise;
- b. Low microseismic noise with road noise;

- c. Intermediate microseismic noise without road noise;
- d. High microseismic noise without road noise.

9.1.5 Detection Capability Comparison

A comparison is being made of the detection capabilities of three systems, defined as follows:

System 1: SZ1-10, Σ SS, Σ SSF;

System 2: MAP I plus Z1-Z3, Z5, Z6, Z10;

System 3: those channels of MAP II which use only elements of the vertical array plus DH1-6, Σ DH, Σ DHF.

An experienced analyst is independently reading seismograms recorded on each system and grading each subsystem as to how well it detected each event recorded by the given system. These data will be used to determine the relative importance of each subsystem's contribution to the system of which it is a part and to evaluate the overall detection capabilities of systems 2 and 3 relative to system 1.

9.2 ARRIVAL TIME RESIDUAL STUDY

During the reporting period, a study of accuracy of arrival time determination, signal detectability, and accuracy of determination of the direction of first motion as a function of signal-to-noise ratio (S/N) was conducted. The data used in this study were taken from the analyses of the synthesized seismograms prepared for the detection capability study, reported in Geotech Technical Report 66-1, Estimates of the Detection Capability of Four VELA-Uniform Seismological Observatories. For the arrival-time residual study, data for one signal (signal 9) occurring in 13 noise types were processed to yield percent detected, percent correct first-motion determinations, and arrival-time residual (analyst pick time-signal occurrence time) frequency distributions as a function of S/N for each noise type and for all noise types combined. Four cases were considered:

- a. Four individual vertical seismograms, a summation seismogram, and a filtered summation seismogram (system 3); S/N determined from an individual vertical seismogram;

- b. System 3: S/N determined from the summation seismogram;
- c. Four individual vertical seismograms and a summation seismogram (system 2); S/N determined from an individual seismogram;
- d. System 2: S/N determined from the summation seismogram.

For case (a) and for all noise types combined, 88 percent of the signal occurrences with S/N greater than 1.0 were detected, and 96 percent of the signal occurrences with S/N greater than 2.0 were detected. For the same conditions and for S/N less than about 8.0, the percent of correct first motion determinations did not increase significantly with increasing S/N. For case (a) and for all noise types combined, the variance of the arrival-time residuals decreased with increasing S/N.

We expect to submit a report on the results of this study to the Project Officer on 1 May 1967.

9.3 SIGNAL CLASSIFICATION STUDY

Significant progress has been made during this reporting period in the study (which was begun under Project VT/5055) designed to develop a system for classifying teleseismic P-wave signals on the basis of their visual characteristics. A preliminary classification system has been developed and applied to approximately 300 teleseismic P-wave signals with magnitudes equal to or greater than 5.0. The classified signals have been recorded on a composite 16-millimeter film and a set of instructions for applying the classification system has been written.

We plan to have analysts at TFSO and UBSO independently classify the signals recorded on the composite film. If results obtained by different analysts are not consistent, we will modify the classification scheme until consistent results are obtained. The results of this study will also be analyzed to determine if the visual characters involved in the classification scheme are independent. If some of the characters turn out to be dependent on the others, the classification scheme will be modified until an independent set of characters is found.

When a satisfactory classification scheme has been developed, we will investigate the effect of variations in signal-to-noise ratio on the categories into which signals are classified.

9.4 LONG-PERIOD NOISE RMS LEVELS RECORDED AT TFSO, UBSO, AND WMSO

Values of rms level of a 40-minute sample of noise recorded on each component of the long-period seismographs at TFSO, UBSO, and WMSO during the reporting interval were calculated. The sample was randomly selected from periods in which no nonseismic noise was present. The rms values were calculated from the time domain signals, with no frequency filtering other than that imposed by the respective seismographs. The frequency responses, shown in figures 7 through 9, are different for the different observatories and even for different components at a given observatory. Therefore, the differences in frequency response of the different seismographs must be considered when comparing the rms values of the different systems. The calculated rms values are presented in table 9.

Table 9. Rms values of randomly selected long-period noise samples recorded at TFSO, UBSO, and WMSO

	<u>Run No.</u>	<u>Date</u>	<u>Seismograph</u>	<u>rms (m μ)</u>
TFSO	56	25 Feb. 67	ZLP	38.0
			NLP	32.9
			ELP	26.0
TFSO	93	3 April 67	ZLP	23.5
			NLP	21.1
			ELP	14.1
UBSO	95	5 April 67	ZLP1	8.4
			NLP1	12.6
			ELP1	9.5
WMSO	99	9 April 67	ZLP	24.4
			NLP	39.1
			ELP	32.5

9.5 LONG-PERIOD ARRAY INVESTIGATION

During the reporting period, we investigated the feasibility and desirability of installing an array of three-component long-period seismographs at UBSO. We investigated the possibility of transmitting data from the seismometers to the central recording building by means of existing telephone lines instead of by means of spiral-four cable and investigated several possible array configurations. When our investigation is complete, we will submit a long-period array recommendation to the Project Officer.

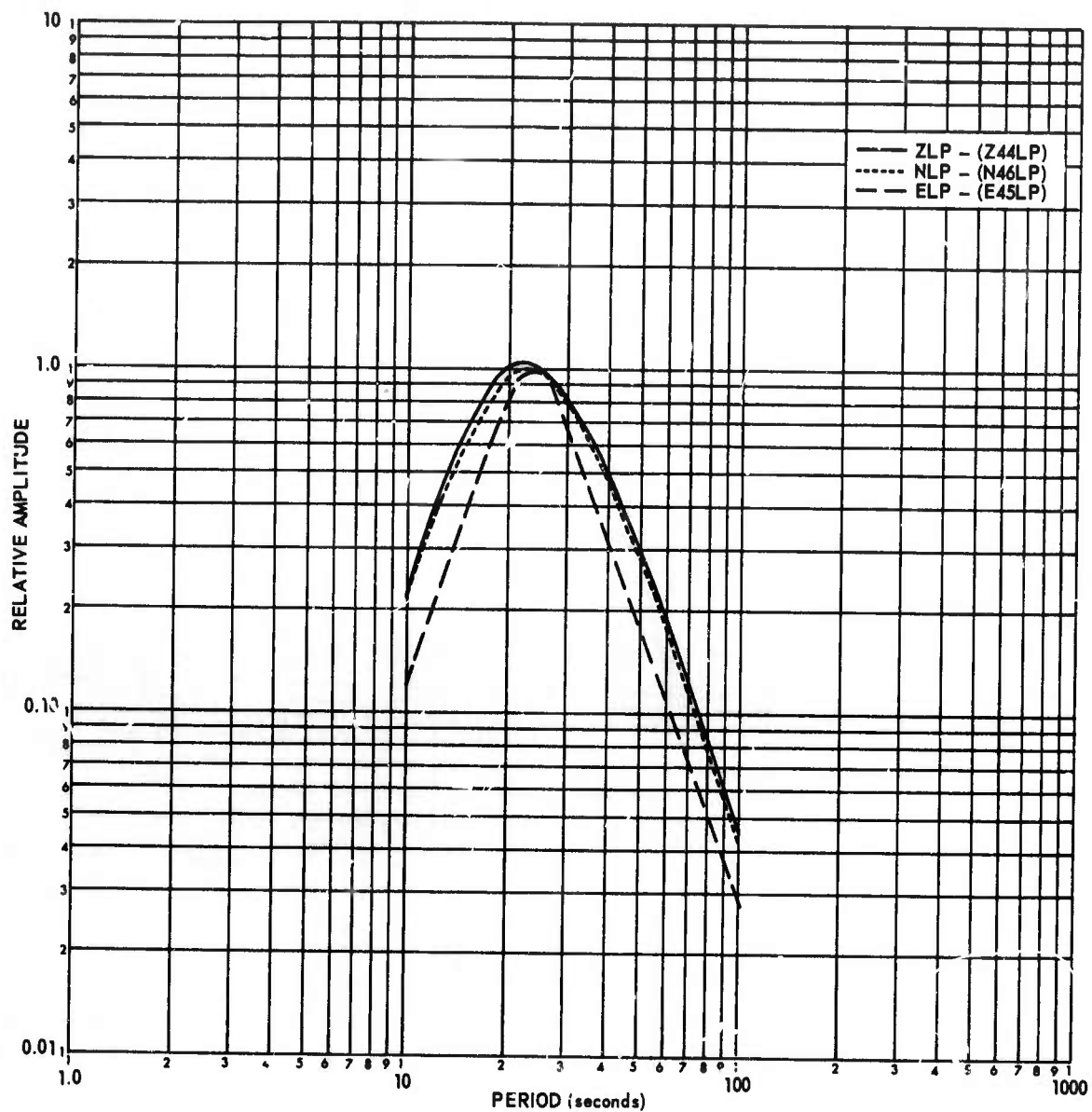


Figure 7. Normalized frequency responses of TFSO long-period seismographs

G 2712

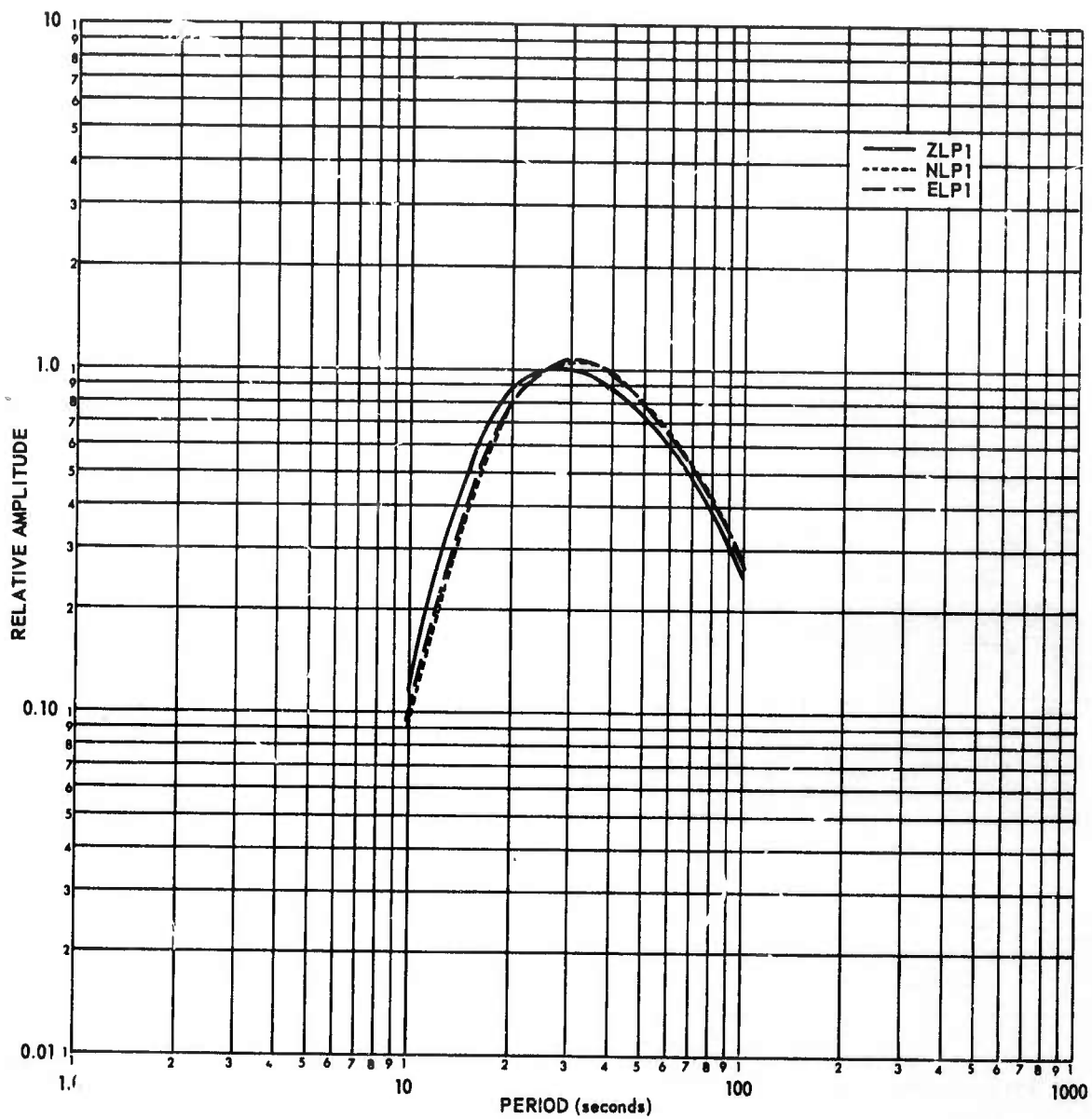


Figure 8. Normalized frequency responses of UBSO long-period seismographs

G 2713

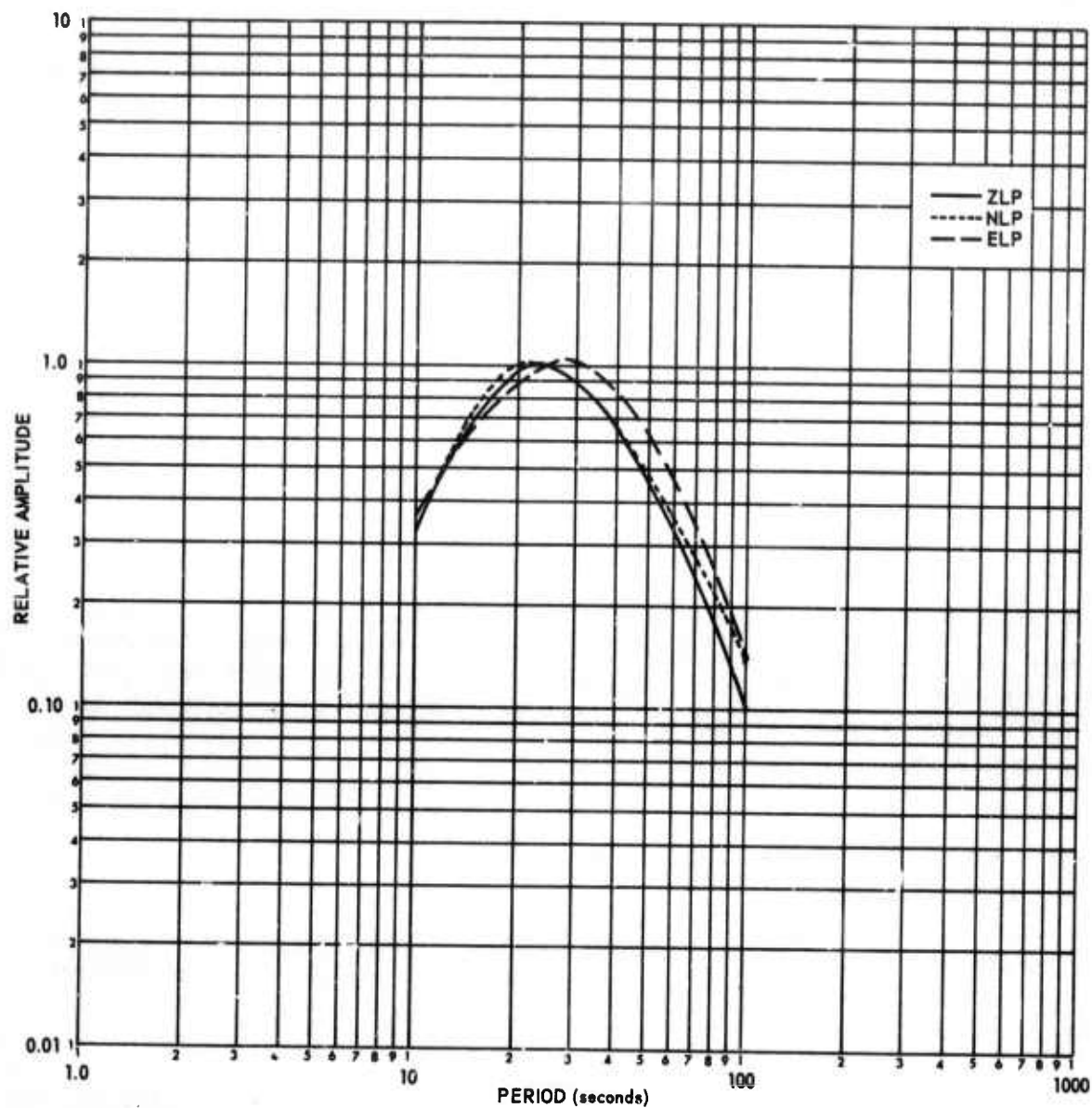


Figure 9. Normalized frequency responses of WMSO long-period seismographs

G 2714

9.6 ROUTINE NOISE MEASUREMENTS

Measurements of ambient noise in the 0.4- to 1.4-second period range are made daily at UBSO. Data are processed in Garland, and monthly cumulative probability curves of trace amplitudes and ground displacement are published. Noise data are reported from the Z10, SZ10, ΣT , ΣST , ΣTF , and ΣSTF seismograms. Noise curves for December 1966 through February 1967 were sent to the Project Officer during this reporting period.

10. PROVIDE OBSERVATORY FACILITIES AND ASSISTANCE TO OTHER ORGANIZATIONS

10.1 NASA SONIC BOOM STUDY

The sonic boom flights over UBSO took place on 2 March, as scheduled. By 7 March, all personnel taking part in the sonic boom study had departed UBSO.

10.2 DATA SENT TO THE UNIVERSITY OF UTAH

With the Project Officer's approval, arrival time, amplitude, and period data for blasts at the Bingham mine which occurred between 5 February and 25 February were sent to Dr. Kenneth Cook, University of Utah, at Dr. Cook's request.

10.3 DELETION OF MAGNETIC TAPE SHIPMENT TO C&GS, ALBUQUERQUE

At the Project Officer's request, the routine monthly shipment of degaussed magnetic tape to the Coast and Geodetic Survey, Albuquerque, scheduled for 15 April, was skipped. The next shipment will be made on 15 May.

10.4 SHIPMENT OF UBSO DAILY MESSAGES TO COLORADO SCHOOL OF MINES

During the reporting period, approval was received from the Project Officer to send copies of the UBSO daily message to the Colorado School of Mines. Copies of the messages will be sent weekly.

10.5 SHIPMENT OF UBSO DAILY LETTER REPORTS TO THE U. S GEOLOGICAL SURVEY

With the Project Officer's approval, copies of the UBSO daily letter reports for the period 1 November 1966 through 24 April 1967 were sent to Dr. C. B. Raleigh, U. S. Geological Survey, Menlo Park, California. Dr. Raleigh is engaged in studies of earthquake generation by the pumping of waste into deep wells for disposal, primarily in the Denver area. Future letter reports will be sent weekly to Dr. Raleigh.

10.6 VISTORS

Mr. John McDonald, Teledyne, was at UBSO from 23 February until 7 March to supervise recording of seismic effects of the sonic booms.

Messrs. A. C. Morgan and H. K. King, Teledyne, were at UBSO from 25 February until 7 March to take part in the sonic boom program.

Mr. Herb Henderson, NASA Langley Research Center, was at UBSO from 25 February until 2 March in connection with the sonic boom program. Mr. Henderson is NASA Technical Supervisor for the sonic boom program.

Messrs. G. D. Davidson, H. D. Sell, and J. N. Perkins, Philco Corp., were at UBSO from 26 February until 2 March installing equipment to monitor overpressure caused by the sonic booms.

Sandia Corporation representatives R. S. Reynolds, D. F. Davis, and G. H. Mauth were at UBSO on 23 March performing maintenance on Sandia's USO.

Mr. Royden Shurtz, Automatic Systems Co., was at UBSO on 23 March to finalize his recommendation for modifications to the UBSO air-conditioning system.

Mr. W. C. Jones, Kemper Insurance Co., inspected all pressure systems at UBSO on 24 March. No discrepancies were found.

Messrs. D. F. Davis and R. W. Dietzel, Sandia Corp., were at UBSO on 28 March, performing maintenance on the USO.

Twenty-nine students and their teacher from the sixth, seventh, and eighth grades of the Dinosaur, Colorado, school visited UBSO on 14 April.

11. REPORTS

Technical Report No. 67-10, Operation of UBSO, Quarterly Report No. 3, Project VT/6705, was mailed to the Project Officer on 21 February.

APPENDIX to TECHNICAL REPORT NO. 67-31

STATEMENT OF WORK

EXHIBIT "A"
STATEMENT OF WORK TO BE DONE
AFTAC Project Authorization No. VELA T/6705/S/ASD (32)

8 February 1966

1. Tasks:

a. Operation:

(1) Continue operation of the Uinta Basin Seismological Observatory (UBSO), normally recording data continuously.

(2) Evaluate the seismic data to determine optimum operational characteristics and make changes in the operating parameters as may be required to provide the most effective observatory possible. Addition and modification of instrumentation are within the scope of work. However, such instrument modifications and additions, data evaluation, and major parameter changes are subject to the prior approval of AFTAC.

(3) Conduct daily analysis of seismic data at the observatory and transmit daily seismic reports to the US Coast and Geodetic Survey, Wash DC 20230, using the established report format and detailed instructions.

(4) Record the results of daily analysis on magnetic tape in a format compatible with the automated bulletin program used by the Seismic Data Laboratory (SDL) in their preparation of the seismological bulletin of the VELA-UNIFORM seismological observatories. The format should be established by coordination with SDL through AFTAC. The schedule of routine shipments of these prepared magnetic tapes to SDL will be established by AFTAC.

(5) Establish quality control procedures and conduct quality control, as necessary, to assure the recording of high quality data on both magnetic tape and film. Past experience indicated that quality control review of one magnetic tape per magnetic tape recorder at the observatory each week is satisfactory unless quality control tolerances have been exceeded and the necessity of additional quality control arises. Quality control of magnetic tape should include, but need not necessarily be limited to, the following items:

- (a) Completeness and accuracy of operation logs.
- (b) Accuracy of observatory measurements of system noise and equivalent ground motion.
- (c) Quality and completeness of voice comments.
- (d) Examination of all calibrations to assure that clipping does not occur.
- (e) Determination of relative phase shift on all array seismographs.

REPRODUCTION

EXHIBIT "A"

- (f) Measurement of DC unbalance.
 - (g) Presence and accuracy of tape calibration and alignment.
 - (h) Check of uncompensated noise on each channel.
 - (i) Check of uncompensated signal-to-noise of channel 7.
 - (j) Check of general strength and quality of timing data derived from National Bureau of Standards Station WWV.
 - (k) Check of time pulse modulated 60 cps on channel 14 for adequate signal level and for presence of time pulses.
 - (l) Check of synchronization of digital time encoder with WWV.
- (6) Provide observatory facilities, accompanying technical assistance by observatory personnel, and seismological data to requesting organizations and individuals after approval by AFTAC.
- (7) Maintain, repair, protect, and preserve the facilities of the seismological observatory in good physical condition in accordance with sound industrial practice.
- b. Instrument Evaluation: After approval by AFTAC, evaluate the performance characteristics of experimental or off-the-shelf equipment offering potential improvement in the performance of observatory seismograph systems. Operation and test of such instrumentation under field conditions should normally be preceded by laboratory test and evaluation.
- c. Special Investigations: Conduct research investigations as approved or requested by AFTAC to obtain fundamental information which will lead to improvements in the detection capability of UBSO. These programs should take advantage of geological, meteorological, and seismological conditions at UBSO. The following special studies should be accomplished.
- (1) Long term evaluation of the multiple array processor units.
 - (2) Installation and evaluation of a vertical array.
 - (3) Evaluation of the long-period vault.
 - (4) Provide technical assistance and monitor an unattended seismological observatory to be installed at UBSO in June 1967.

Research might pursue investigations in, but is not necessarily limited to, the following areas of interest: microseismic noise, signal characteristics, data presentation, detection threshold, and array design (surface and shallow borehole). Prior to commencing any research

EXHIBIT "A"

investigation, AFTAC approval of the proposed investigation and of a comprehensive program outline of the intended research must be obtained.

2. Approval by AFTAC will normally be provided through the project officer.

3. Reports: Provide reports in accordance with the ^{Data} requirements outlined in DD Form 1423 and attachment 1 thereto.

REPRODUCTION

AF 33(657)-16563

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)

GEOTECH, A Teledyne Company
3401 Shiloh Road
Garland, Texas

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

3. REPORT TITLE

Operation of UBSO
Quarterly Report No. 4, Project VT/6705, 1 February 1967 through 30 April 1967

4. DESCRIPTIVE NOTES (Type of report & inclusive dates)

Quarterly Report No. 4, Project VT/6705, 1 February 1967 through 30 April 1967

5. AUTHOR(S) (Last name, first name, initial)

Leichliter, B. B.

6. REPORT DATE

19 May 1967

7a. TOTAL NO. OF PAGES

50

7b. NO. OF REFS

8a. CONTRACT OR GRANT NO.

AF 33(657)-16563

b. PROJECT NO.

VELA T/6705

c.

ARPA Order No. 624

d. ARPA Program Code No. 6F10

8a. ORIGINATOR'S REPORT NUMBER(S)

8b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES

This document is subject to special export controls and each transmittal to foreign governments or foreign national may be made only with prior approval of the Chief of AFTAC

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

Advanced Research Projects Agency
Nuclear Test Detection Office
Washington, D. C.

13. ABSTRACT

This report described the operation of the Uinta Basin Seismological Observatory from 1 February 1967 through 30 April 1967. Modifications and additions to the observatory instrumentation are described, and tests to improve the operation of the observatory are reported. Also discussed is the status of special investigations designed to evaluate and improve the detection capability of the observatory.

14.

KEY WORDS

Unattended Seismological Observatory
Vertical Array
Multichannel Array Processor
Seismograph Operating Parameters

LINK A

ROLE WT

LINK B

ROLE WT

LINK C

ROLE WT

INSTRUCTIONS

1. **ORIGINATING ACTIVITY:** Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization (corporate author) issuing the report.

2a. **REPORT SECURITY CLASSIFICATION:** Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. **GROUP:** Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. **REPORT TITLE:** Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. **DESCRIPTIVE NOTES:** If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. **AUTHOR(S):** Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. **REPORT DATE:** Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7a. **TOTAL NUMBER OF PAGES:** The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. **NUMBER OF REFERENCES:** Enter the total number of references cited in the report.

8a. **CONTRACT OR GRANT NUMBER:** If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. **PROJECT NUMBER:** Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. **ORIGINATOR'S REPORT NUMBER(S):** Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. **OTHER REPORT NUMBER(S):** If the report has been assigned any other report numbers (either by the originator or by the sponsor), also enter this number(s).

10. **AVAILABILITY/LIMITATION NOTICES:** Enter any limitations on further dissemination of the report, other than those

imposed by security classification, using standard statements such as:

- (1) "Qualified requesters may obtain copies of this report from DDC."
- (2) "Foreign announcement and dissemination of this report by DDC is not authorized."
- (3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through _____."
- (4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through _____."
- (5) "All distribution of this report is controlled. Qualified DDC users shall request through _____."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. **SUPPLEMENTARY NOTES:** Use for additional explanatory notes.

12. **SPONSORING MILITARY ACTIVITY:** Enter the name of the departmental project office or laboratory sponsoring (paying for) the research and development. Include address.

13. **ABSTRACT:** Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as (TS), (S), (C), or (U).

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. **KEY WORDS:** Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.